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THE IMPORTANCE OF TELLURIUM AS A HEALTH HAZARD IN INDUSTRY—A PRELIMINARY REPORT.

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The purpose of this paper is to invite the attention of industrial hygienists and physicians to the importance of tellurium as an industrial health hazard. Before proceeding with this subject, however, we deem it advisable to give a résumé of the chemistry of this element.

Chemistry.

Early history.—Although tellurium was first recognized as a distinct element by Klaproth in 1798—16 years after Müller von Reichenstein had first suspected the presence of a new metal in an auriferous mineral from Transylvania—not a great amount of knowledge of the element is available. The element was carefully studied by Berzelius in 1826, and since that time very little has been contributed concerning it. This in the past was, no doubt, due to the fact that the metal was scarce, since the only method of obtaining it was a very lengthy one of extraction applied to large masses of ores. Even when tellurium was so obtained, it was not certain that it was the same as had been previously described, because of the fact that the methods of purification were very crude and imperfect.

Chemists have been given the opportunity to study tellurium closer of late years because it is now obtained from the dross produced in electro-refining. The slime which settles to the bottom of the electrolytic tanks is treated to recover the more precious metals, and the residuum is then treated to obtain the tellurium by a method which will be described later.

Occurrence.—Tellurium occurs in the free state alone in small quantities in some minerals. More frequently it is found in the free state associated with gold, silver, selenium, or iron, but is usually combined with some metal as the telluride. Crystals of pure tellurium are rare in nature, but they do exist. They are usually minute hexagonal prisms with rhombohedral terminations, commonly massive, columnar to fine granular, with perfect prismatic cleavage. The most important telluride sources of tellurium are, tetradymite, $BiTe_3$; altaite, PbTe; coloradoite, HgTe; calaverite, $AuTe_2$; sylvanite, $AuAgTe_4$; petzite, Ag_3AuTe_2; and nagyagite, $(AuPb)_2(TeSSb)_3$.

With sylvanite the metal is found at Zalathna, Transylvania, and Vulcan, Colo.; also with gold ores at Offenbanya and Nagyag in Transylvania, Kalgoorlie in West Australia, Virginia, California, and Cripple Creek, Colo. Other minerals containing tellurides are found in Mexico, Chile, Brazil, Honduras, and Asia Minor. Native tellurite, TeO_2, or tellurium ocher, is found, and about 17 per cent of tellurium has been found, in the red sulphur of Japan.

Modes of formation.—Tellurium may be prepared from its minerals or from the residue in several metallurgical processes. It may be obtained from bismuth telluride by mixing it, finely powered, with sodium carbonate, rubbing it up with oil to a thick paste, calcining in a closed crucible, lixiviating with cold water, and blowing a current of cold air through the aqueous solution of the resultant sodium telluride. The tellurium then separates out as a gray powder.

Other tellurides are attacked by hydrochloric acid. The insoluble residue from them is heated with concentrated sulphuric acid, and from the dilute sulphate solution, after removing the silver as a chloride, the tellurium is precipitated by means of zinc oxide or sulphur dioxide. The alkaline residues from the bismuth ores may be acidified with hydrochloric acid and treated with sodium sulphide to precipitate the tellurium.

Tellurium may also be extracted from the slime resulting from the electro-refining of copper and lead, and some other metals. This slime settles to the bottom of the electrolytic tanks during the process of refining. It is treated to remove the metals of more value, and the residuum is subjected to repeated leaching with hydrochloric acid. It does not seem that heat aids in this step. The slime is then filtered through a filter press, and the resultant bright yellow filtrate treated with sulphur dioxide to precipitate the tellurium. By this process the selenium, which is very frequently present with the tellurium through all of the above steps in the recovery, is precipitated along with the tellurium by the sulphur dioxide. Complete precipitation is not obtained because of the rapid increase of the acid content of the solution, caused by the hydrochloric acid being set free, and also the sulphuric acid formed and liberated. By evaporation of the liquid the hydrochloric acid can be driven off, and an additional precipitation is then obtained. Further precipitation can be caused by acid sodium sulphite. After this has been done, heating will cause more precipitation of the tellurium without the addition of a precipitant.

Metallic magnesium will completely precipitate the tellurium from a solution of the tetrachloride in hydrochloric acid. The excess of hydrochloric acid should be small and a slight excess of magnesium should be added. This latter can be easily destroyed by

heating or boiling, when it decomposes to form magnesium hydroxide, which can be removed by neutralization with acetic acid.

Tellurium can be recovered from a mixture of selenium and tellurium by the action of electrolytic chlorine. The tellurium, being the more metallic of the two elements, is more readily attacked and converted into the chloride at low temperatures to the exclusion of the selenium.

Properties.—Tellurium is a bluish-white silverlike element possessing metallic luster. Its atomic weight is 127.6. It is a poor conductor of heat and electricity. Its specific gravity is 6.26. It melts at 452° C. When slowly cooled from the molten state it forms hexagonal rhombohedral crystals, isomorphous with sulphur and selenium. When heated in the air it burns with a blue flame to form tellurous oxide (TeO). When heated in a sealed tube it sublimes to form prismatic crystals. Tellurium is very brittle and has a hardness of from 2 to 2.5. It boils at a red heat and volatilizes readily when heated in a stream of oxygen. In an almost perfect vacuum it boils at 478° C. The vapor of tellurium is golden yellow and consists of diatomic molecules. Tellurium is precipitated by reducing agents in an amorphous form which has a specific gravity of 6.015. When heated this is converted into the crystalline form with the evolution of heat. By careful reduction of dilute solutions of tellurium salts, brown and blue colloidal solutions may be obtained.

Tellurium is not attacked by hydrochloric acid, but reacts readily with nitric and sulphuric acids and concentrated potassium hydroxide. It is insoluble in carbon disulphide. Tellurium reduces solutions of gold and silver salts and reacts with thionyl chloride and similar chlorides to form the tetrachlorides.

In physical properties tellurium resembles the metals, but in chemical properties it is decidedly nonmetallic. It forms one of the oxygen family of elements and is closely related to sulphur and selenium of the same family.

Acids of tellurium and their salts.—Berzelius, in the early part of the nineteenth century, showed that tellurium forms two oxygen acids—namely, tellurous acid, H_2TeO_3 and telluric acid, H_2TeO_4, of which he prepared the latter acid and showed it to have the composition H_2TeO_4–$2H_2O$. Tellurous acid may be prepared by pouring a solution of tellurium in nitric acid into an excess of water, the acid being precipitated out as a white amorphous powder. Berzelius prepared a great number of the salts of both tellurous and telluric acids, and demonstrated that nearly all of the metals yield insoluble salts with these acids. The soluble tellurates of sodium, potassium, and cerium received the greater amount of the attention of subsequent workers. Hutchins did extensive studies upon the tellurates of potassium, mercury, zinc, copper, and silver. Although telluric

acid is a weak acid, hot concentrated solutions of it will attack mercury, silver, lead, tin, arsenic, antimony, bismuth, nickel, zinc, aluminium, and cadmium. Telluric acid forms a number of complex superacid salts, such as normal potassium tellurate, K_2TeO_4–$5H_2O$; hydrogen potassium tellurate, $HKTeO_4$; quadracid potassium tellurate, K_2TeO_4–H_2TeO_4–$3H_2O$; and potassium tetratellurate, K_2TeO_4–$3H_2TeO_4$–H_2O. Telluric acid may be prepared by fusing either tellurium or tellurium oxide with a mixture of potassium nitrate and potassium carbonate: $Te + K_2CO_3 + 2KNO_3 = 2K_2TeO_4 + N_2 + CO$. The fused mass after solution in water is mixed with a solution of barium chloride, which precipitates barium tellurate, this being decomposed by the addition of the exact amount of sulphuric acid. After filtration the clear filtrate deposits crystals of telluric acid, H_2TeO_4–$2H_2O$. Upon being heated to 160° C. these crystals lose their water and the anhydrous acid in the form of powder is left.

Tellurous acid gives rise to both acid and normal salts; thus with potassium it forms hydrogen potassium tellurite, $HKTeO_3$ and dipotassium tellurite, K_2TeO_3. It forms superacid salts such as quadracid potassium tellurite, $HKTeO_3$–H_2TeO_3, and potassium tetratellurite, K_2TeO_3–$3TeO_2$.

Tellurides.—Sir Humphrey Davy during the course of his studies upon the alkali metals prepared the tellurides of sodium and potassium by direct union and the reduction of mixtures of the alkali carbonates and tellurium oxide with water. He describes them as alloys of the metals with tellurium, stating that they dissolved in water to a dark-red color and when acidified yielded a gas similar to hydrogen sulphide. Berzelius prepared hydrogen telluride, obtaining red solutions also, by absorbing the hydrogen telluride in fixed alkalis.

Hydrogen telluride may be prepared by heating tellurium in hydrogen. These elements combine to form H_2Te, which exhibits properties of being decomposed by heat and depositing the element as a crystalline sublimate. Hydrogen telluride may also be obtained by the action of hydrochloric acid upon zinc telluride: $ZnTe + 2HCl = ZnCl_2 + H_2Te$: It precipitates metals from their solution as does hydrogen sulphide. It is soluble in water, the resulting solution gradually absorbing oxygen from the air and the tellurium precipitating out.

Halogen compounds.—Two chlorides of tellurium are known, $TeCl_2$ and $TeCl_4$. Corresponding bromides and iodides have been prepared.

Organic compounds of tellurium.—There have been a few organic compounds of tellurium prepared, such as dimethyl telluride, $Te(CH_3)_2$; diethyl telluride, $Te(C_2H_5)_2$; and dinapthyl telluride, $Te(C_{10}H_7)$.

Tests for presence of tellurium.—1. Acid sodium sulphite will indicate the presence of tellurium in solutions where there is as small an amount as 0.000000214 gm. of tellurium per cc. of solution. The test is performed by treating the tellurium with hydrochloric acid, with the aid of as little chlorine gas as possible, and then heating it to expel the excess of chlorine. Acid sodium sulphite is added to the solution, and it is then filtered. The black precipitate showing on the filter paper is tellurium, which may be confirmed by further tests.

2. When tellurium is heated on charcoal a white sublimate of tellurium is formed. It is volatile, and when touched with the reducing flame it gives the flame a pale greenish color.

3. When a telluride is heated in concentrated sulphuric acid it gives a deep crimson color to the solution. The color will disappear if the acid is heated too hot, or if after cooling the solution is diluted with water.

Industrial preparation of tellurium.—The methods used for the industrial preparation of tellurium have been outlined above, the chief method consisting in repeated leaching of the residuum left after the more valuable metals have been recovered from the slime obtained from the electrolytic tanks in electrorefining plants, and the precipitation of the tellurium by sulphur dioxide. It is not necessary to further describe the method at this time.

In 1916 there was practically no demand for tellurium, and hence the production of the metal was curtailed. The selling price at that time was from $3 to $5 a pound.

In 1917 two companies reported the production of small amounts of tellurium. The prevailing selling price of tellurium at that time was around $3 a pound.

It must be mentioned that the slimes from the electro-refining of lead contain larger amounts of tellurium than of selenium, which almost always accompanies tellurium, while the slimes from the copper electro-refining tanks contain a larger percentage of selenium than of tellurium.

Industrial uses of tellurium.—Tellurium has not as yet been used to a great extent in industry. Many research organizations and individual investigators are attempting to discover means whereby it can be advantageously used, but no wide use has been suggested up to the present time. It has been used in a medicinal way to some extent, but the largest use in the past has been in the glass industry. During the year 1917 considerable quantities of tellurium were bought by glass makers. Tellurium gives a blue, red, or brown color to glass, depending upon the method of its use. It acts as a coloring agent in glass only under reducing conditions, in which case it gives rise to blue or brown colorations if present as a colloidal solution of

the element, or a red color if present as the telluride. The colloidal particles in the blue glass are larger than those in the brown.

The reducing property of tellurium has also been utilized to a small extent, at least experimentally, in the steel industry, where it functions in much the same way as coke. It has also been used somewhat in bacteriological work as an indicator of bacterial life. Here, again, its reducing property is utilized.

TELLURIUM AS AN INDUSTRIAL POISON.

Although a large amount of experimental work has been done with tellurium both in chemical and physiological studies, it apparently never got beyond the laboratory stage. It did not seem to occur to anyone that tellurium might act as an industrial poison. This may be due to the fact that only recently has it been encountered industrially in fairly large quantities.

Occurring as it does as an impurity in copper and lead ores, it is in the refining of these metals that it is now met with in greatest amounts. Perhaps its most fruitful source is in the electrolytic refining of lead. In this industry it occurs as fumes in the form of hydrogen telluride, and as dust in the form of tellurous oxide and the tellurates.

The possibility that tellurium might act as an industrial health hazard first came to our attention in the fall of 1918. We were then making a study of lead poisoning in an electrolytic lead refinery. During this study it was noted that practically all of the men examined from one department smelled strongly of garlic. At first this odor really was attributed to garlic, until we ascertained that no garlic had been eaten by these men. Further investigation revealed that a number of these men complained of a dry skin and a loss of the sweat function. As such findings could not well be attributed to lead poisoning, we sought to discover their true cause, which after investigation we assigned to tellurium. No other men in the plant complained of such symptoms, and no others came into contact with tellurium.

Exposure.—The men in question were working in the silver refinery around blast furnaces and were subjected to high temperatures. Here the slime from the electrolytic tanks was treated to remove the Doré metal, and tellurium was encountered as an impurity. The temperature attained in the blast furnaces was about 1,200°–1,400° F., and tellurium fumes were given off probably in the form of hydrogen telluride, a compound analogous to sulphuretted hydrogen and arseniuretted hydrogen. Tellurium also was present in the dust about the furnaces, probably in the form of the oxide and telluride.

Entrance into body.—The main canals of entry into the body are therefore through the respiratory and the alimentary tracts. Some of

the dust undoubtedly finds its way into the lungs along with the fumes, but the greater portion of it is caught in the nasopharynx and swallowed. Lehman and Saito have shown experimentally that when dust is breathed, only 12 per cent reaches the lungs, whereas 70 per cent reaches the alimentary canal. We are inclined to believe that the salts of tellurium can also be absorbed through the skin. This seems to be particularly true of tellurous acid, as a short time after this substance has been handled the garlic odor of methyl telluride appears on the breath.

Fate in the body.—Experimental work has shown that after the salts of tellurium have gained entrance to the body through any of the above channels, they are first reduced to the metallic tellurium. Following this reduction, a methyl telluride is formed, which is very volatile and gives the peculiar garlic odor to the secretions and excretions. The synthesis of methyl telluride is one of the few known cases in which a compound of methyl is formed in the animal body. Experimentally, the greatest toxic effects of tellurium are exerted during the reduction of the salts. Reduced tellurium, however, can also exert toxic effects, although somewhat slowly.

Excretion.—The intestinal contents are pigmented by reduced tellurium, and much of the ingested substance is eliminated in the feces in metallic form; in the exhaled breath, urine, feces, and dermal secretions, as methyl telluride; and in small quantities in the urine and bile, in a soluble form.

Pathology and symptomatology.—Inasmuch as we have not yet been able to study the pathology of tellurium poisoning upon human subjects, we must rely upon the results of animal experimentation for this information.

We know that in man tellurium causes a suppression of the secretion of saliva and of the sweat. In animals even small doses markedly reduce the secretion of acid in the gastric juice and stimulate the secretion of mucus in the stomach and intestines. These effects are apparently due to a paralysis of the terminations of the secretory nerves similar to that induced by atropin. The capillaries of the splanchnic area are dilated as with arsenic. In more severe poisoning in animals there is inflammation and disintegration of the mucous membrane of the gastro-intestinal tract, with intestinal hemorrhages. There is an intense hyperemia of the organs, with multiple hemorrhagic foci. Before death there is an intense degeneration of the red cells, with a diminution of hemoglobin. Myelocytes, normoblasts, and other cells denoting destruction and regeneration of the red cells, may be found. There may also be considerable leucocytosis. As a result of the increased fragility and destruction of the red cells, large quantities of urobilin, together with some hemoglobin, are usually found in the urine. In many instances a large quantity of some

reducing substance is present. Some observers state that this is sugar and that it is associated with a hypoglycemia, thus differing from ordinary glycosurias. Others assert that there is no glycosuria, inasmuch as the reducing substance can be destroyed by the addition of acetic acid and lead acetate. Large doses produce some albuminuria due to a parenchymatous nephritis.

Knowing the pathology of tellurium poisoning, it is an easy matter to account for the resulting symptoms. In the chronic cases there is retarded gastric digestion, vomiting, loss of appetite, emaciation, and somnolence. Most animals lose an appreciable quantity of hair, due probably to diminished nutrition of the skin or to a decrease in the function of the sebaceous glands. In severe acute poisoning, there is vomiting, purging, weakening of reflexes, tremor, somnolence, followed by paralysis of the central nervous system, unconsciousness, dyspnœa, and death from asphyxia in tonic and clonic convulsions.

In man the symptoms thus far noted have been a garlic odor to the sweat and alvine discharges, dryness of the mouth, nausea, vomiting, metallic taste, somnolence, depression, constipation, and a suppression of the sweat function. As a result of the latter, the skin may become harsh and dry, and a troublesome pruritus result. The garlic odor, dryness of the mouth, metallic taste, and somnolence are early symptoms, and follow very small doses. With us they followed the ingestion of a single dose of 2 grains of tellurous oxide, and the garlic odor persisted for two and a half months. The other symptoms disappeared after about two or three days. At another time a man spilled a small container of tellurous oxide, and while scraping it up from the floor onto a paper without allowing his fingers to come into contact with it, absorbed enough tellurium (presumably through the respiratory system) to give a garlic odor to his breath for over a week and a bitter taste in his mouth for nearly two days.

As an illustration of the somnolent effects of the element, an experience of Prof. Lenher is of interest. One day, after having fused metallic tellurium in the open for several hours, he was so overcome by the influence of the volatile oxide that he lay down on his bed to sleep for a little while, expecting to arise shortly and resume his work. He slept for 18 hours, however, without waking once during that time.

Such experiences indicate a possible therapeutic use for tellurium salts as hypnotics. Their efficacy in inhibiting the sweat function has been utilized with some success in the treatment of night sweats in tuberculosis. They might also be used to diminish the acid secretion of the stomach in cases of hyperacidity. However, because of the strong garlic odor to the breath, which persists for weeks and months, and the bitter metallic taste in the mouth, they are not to be recommended.

In passing, it is of interest to note that, during the first decade of the present century, Wassermann and others aroused some enthusiasm through experiments with tellurium on malignant growths. Thiroloix and Lancrin used a colloid preparation in experiments with epitheliomata, and asserted that it led "in a brief time to reduction and disintegration of the tumefactions and metastases." In these cases the "tumors softened, the elements of their tissue, and particularly the cells, disappeared, and this disappearance was not preceded by the phenomena of necrosis and degeneration which, more or less extended, are met with in all tumors; but was brought about by a dissolution of all the cell, which began with destruction of the nucleus." The early enthusiasm created by such work has, however, not been justified by later experiments.

To sum up, then, the symptoms of tellurium absorption may be listed as follows: Garlic odor to the breath, sweat, and alvine discharges, dryness of mouth, metallic taste, nausea, anorexia, loss of weight, constipation or diarrhea, suppression of the sweat, and a dry, itching skin. Associated with these symptoms are likely to be an hypoacidity of the gastric juice, with a mild gastro-enteritis and parenchymatous nephritis. Inasmuch as the symptoms of mild tellurism are the same for man and the laboratory animals, we have reason to believe that the more severe effects, as well as the pathological changes, would likewise be similar. As yet we have met with no *severe* cases of tellurium poisoning; but we should expect such cases to exhibit violent vomiting, purging, intestinal hemorrhages, loss of reflexes, tremors, extreme depression, and finally paralysis of the central nervous system, with unconsciousness, dyspnœa, and at last death in convulsions. Associated with these symptoms there would be destruction of the red blood cells, decreased hemoglobin content, hemorrhages into the various organs, and a severe gastro-enteritis and nephritis.

Extent of the hazard.—With this much as a basis, we endeavored to learn the extent of the hazard exerted by tellurium on the workers exposed. To this end all of the men in that department were examined for evidences of absorption of and poisoning by this metal. The results of the examinations are indicated in the accompanying table. It will be noted that, of the 13 men examined, 7 showed evidences of tellurium absorption as indicated by garlic odor to the breath, sweat and urine, dryness of the mouth, and metallic taste. Five of these had a considerable inhibition of the sweat function, and the 2 who did not, had worked only 2 weeks. Three of the 5 had a dry, itching skin, anorexia, nausea, some vomiting, and some degree of depression or somnolence. It is thought that these 3 may be taken as showing evidences of mild tellurium poisoning.

Examination of workers exposed to tellurium.

	Number of worker.												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Occupation	L.	S.	L.	S.	L.	S.	L.	L.	L.	S.	S.	H.	S.
Length of service	2 wks.	7 mos.	7 wks.	4 mos.	2 yrs 7 mos.	3½ mos.	2 mos.	3 wks.	9 wks.	2 wks.	2 wks.	9 mos.	1 yr. 4 mos.
Nationality	P.	P.	P.	P.	H.	P.	B.	H.	P.	P.	P.	A.	P.
English-speaking	—	—	—	—	—	—	—	#	#	#	#	#	—
Appetite	#	Poor.	#	#	#	#	#	#	#	Poor.	#	#	Poor.
Nausea	0	#	0	0	0	0	0	0	0	#	0	0	#
Vomiting	0	Some.	0	0	0	0	0	0	0	#	0	0	Some.
Constipation	0	#	0	#	#	0	0	0	#	#	0	0	#
Diarrhea	0	0	0	0	0	0	0	0	0	0	0	0	0
Dry mouth	0	#	#	0	0	0	0	0	#	#	#	#	#
Metallic taste	0	#	#	0	0	0	0	0	#	#	#	#	#
Dry, itching skin	0	# Rash.	# Rash.	0	0	# Rash.	0	0	0	# Rash.	0	# Rash.	# Rash.
Suppression of sweat	0	#	#	0	0	0	0	0	#	0	0	#	#
Somnolence	0	#	0	0	0	0	0	0	0	Some.	0	0	#
Blood in feces	0	0	0	0	0	0	0	0	0	0	0	0	0
Reflexes	0	0	0	0	0	0	0	0	0	0	0	0	0
Loss of hair	0	#	0	0	0	0	0	0	0	0	0	0	0
Odor of breath	Natural.	Garlic.	Garlic.	Natural.	Natural.	Natural.	Natural.	Natural.	Garlic.	Garlic.	Garlic.	Garlic.	Garlic.
Odor of sweat	Natural.	Garlic.	Garlic.	Natural.	Natural.	Natural.	Natural.	Natural.	Garlic.	Garlic.	Garlic.	Garlic.	Garlic.
Odor of urine	Natural.	Garlic.	Garlic.	Natural.	Natural.	Natural.	Natural.	Natural.	Garlic.	Garlic.	Garlic.	Garlic.	Garlic.
Albuminuria	0	0	0	0	0	0	0	0	0	0	0	0	0
General nutrition	G.	G.	G.	G.	G.	G.	G.	G.	G.	F.	G.	G.	G.
Susceptibility to heat exhaustion	None.	None.	None.	None.	None.	None.	None.	None.	None.	None.	None.	None.	None.

NOTE.—In order to avoid confusion everything has been eliminated from this table which does not relate to tellurium effects.
Occupations: L=laborer; S=shiftman; H=handyman. *Nationalities:* P=Polish; B=Bulgarian; A=Austrian; H=Hungarian.
G=good; F=fair; #=Yes or Normal (consider the connotation); —=No

It is worthy of note that six of the men examined had a rash. This rash was distributed quite generally over the body, and it is probable that the dry skin, incident to the complete or partial suppression of the sweat function, had something to do with its inception. Their condition is somewhat parallel to that which occurs when the normal fat content of the skin is removed because of contact with certain types of cutting oils. The normal resistance of the skin to light infection is thereby removed, and various grades of infection and dermatitides frequently result.

It is to be noted that 8 of the 13 could not speak English, and so histories were elicited only with great difficulty. Perhaps if a good interpreter had been at hand more evidences of tellurium poisoning would have been discovered.

Attention is invited to the length of service of the men exposed. The tenure of employment of the majority of them was very short, so that in a number of cases the mild chronic effects of tellurium could scarcely have had time to make themselves felt. No. 5, who had worked here for the longest period (2½ years) was exposed only at rare intervals to the hazard.

The garlic odor on the 7 men mentioned above was very marked. In fact, so marked was it that a number of people who were in the habit of riding on the same street car which took these men to and from work complained to a member of the local council about "the foreigners who ate so much garlic riding on the street cars with other people."

Taken by themselves, the effects which these men exhibited do not seem very severe, and if they were all that are to be considered we should probably not deem tellurium poisoning of much importance. There are several important secondary effects, however, which must be considered. It must be remembered that in their work these men are subjected to high temperatures and are therefore exposed to the possibility of heat exhaustion. Since tellurium inhibits the sweat function, the exposure to the fumes and dust of tellurium renders these men more susceptible to heat exhaustion. Reference to the table will show that none of these men had apparently an increased susceptibility to heat exhaustion, but it must also be noted that only one of them (No. 13) had worked long enough to know whether he was more susceptible or not. The examinations were made in the very early spring before the "season" for heat exhaustion had arrived, and the remainder of the men had worked such a short time that they had not yet passed through any of the really hot periods which come during the summer months. The negative answers to this question are therefore not significant.

Another effect which we may expect from prolonged exposure to tellurium is impaired nutrition, due to the more or less complete inhibition of the secretion of saliva and the other digestive juices. Some of the men examined already had digestive disturbances, as evidenced by anorexia, nausea, and vomiting, but the condition had not progressed sufficiently far to cause emaciation or chronic dyspepsia, probably because of the fact that the men had not been exposed to the poison for sufficiently long periods of time. The same is true of nephritis and anemia.

Diagnosis.—From the foregoing it is evident that many of the effects of tellurium absorption are similar to those produced by arsenic, antimony, selenium, and lead. Inasmuch as these metals are nearly always present with tellurium industrially, it may become quite a problem to be able to say definitely which metal is causing the symptoms. Several symptoms of tellurium poisoning are, however, quite distinctive. These are (1) suppression of sweat, (2) dryness of the mouth, and (3) the very pronounced garlic odor to the excretions. Ingestion of arsenic may give a garlic odor, but it is very faint as compared with that produced by tellurium, and requires much larger doses to produce.

If in doubt, positive evidence of tellurium absorption may be obtained by tests of the urine and feces, which contain methyl telluride. The feces also contain metallic tellurium. The presence of methyl telluride may be ascertained by heating the urine or feces with concentrated sulphuric acid, when a crimson color will result. For this test to be positive, however, the methyl telluride must be present in fairly large amounts. The acid sodium sulphite test for metallic tellurium may be used, as described in a preceding paragraph.

Prevention.—This is much the same as for other metallic poisons.[1] It consists in the supplying of proper working conditions by the employer and the observance of proper rules of hygiene by the employee. Adequate natural and artificial ventilation is essential, so that fumes may be removed at their source. Respirators should be furnished and the men required to wear them when working in dusty atmospheres, as when cleaning flues. Competent medical supervision is becoming more and more of a necessity in all industries, and is doubly important where the workers are exposed to industrial poisons. Adequate drinking and washing facilities, together with separate lunch rooms and locker rooms, should be provided. Particular attention should be paid to tellurium poisoning during the summer months when the danger of heat exhaustion is at its height. The men should be watched carefully for symptoms and withdrawn from exposure to high temperatures as soon as they begin to exhibit tellurium effects.

[1] A note on "Precautionary Measures to Prevent Lead Poisoning" was published in Public Health Reports, Dec. 19, 1919, pp. 2905–2907.

The education of the workers in matters of personal hygiene should be one of the aims of the medical departments of all industries, for by this means many industrial as well as other diseases would be prevented. In order to reduce the ingestion of tellurium dust to a minimum, eating in workrooms should be prohibited and the men should be required to wash carefully before eating. Proper care of the skin and bowels should be insisted upon, so that the avenues of elimination may be left open.

Treatment.—The most important factor is removal of the cause. If the case is mild and gastro-enteritis has not yet developed, all that is necessary may be to administer laxatives to keep the bowels open. If the case is more severe and there is diarrhea from the gastro-enteritis, a liquid diet is indicated, together with the administration of bismuth. The patient should be urged to drink water copiously in order to favor excretion. For the same reason sweating should be induced. If hot drinks, hot baths, and hot packs are unavailing, pilocarpin hydrochloride, $\frac{1}{8}$ grain, may be injected hypodermically. This will serve to counteract the effect of tellurium upon the secretory nerves of the skin and will promote copious sweating. It will also serve to stimulate the secretory nerves of the gastro-intestinal tract, thus relieving the hypochlorhydria caused by the tellurium and improving digestion. Until the gastric secretion is restored, dilute hydrochloric acid may be given as a temporary measure to relieve the dyspepsia.

If the case is sufficiently severe to cause anemia, iron may be indicated.

Other treatment is symptomatic, the various symptoms being met as they arise.

Prognosis.—The chronic symptoms will gradually disappear if the source of the poisoning is promptly removed as soon as the diagnosis is made. Unless the poisoning has been very severe, it is not likely that any of the effects will persist long after the removal of the cause. Even in the more severe cases, the nephritis, being parenchymatous, will clear up. Until tellurium is manufactured upon a much larger scale it is not likely that the severe acute poisoning or the more severe effects of chronic poisoning will occur. The prognosis for this type of poisoning must therefore be based upon animal experimentation and would in the main be unfavorable.

Summary.

Until within recent years tellurium was considered only as more or less of a chemical curiosity. With the development of the electrolytic-refining industry, however, its production has increased, and it can no longer be considered a rare element. As yet no very important industrial use has been found for it; but numerous research

organizations, among them the National Research Council, are attempting to discover ways in which it can be used on a large scale in industry. At present at least one large corporation has erected a plant for the sole purpose of isolating and refining tellurium. With the further development of such activities it is to be expected that the production of tellurium will greatly increase and that concomitantly there will be an increase in the health hazard incident to the increased exposure of the workers. We might then expect to encounter the severe effects of tellurium poisoning, such as are now manifested by laboratory animals under the influence of fairly large doses of tellurium.

The tellurium poisoning encountered thus far in industry has not been severe. The primary effects are suppression of the sweat, of the saliva, and of the acid in the gastric juice. This leads to a dry, itching skin, dry mouth, metallic taste, anorexia, nausea, vomiting, indigestion, and constipation. Somnolence is often a prominent symptom. The earliest symptom of tellurium absorption is the garlic odor to the secretions and excretions due to methyl telluride. Secondary effects to be expected are impaired nutrition with emaciation and, where the workers are exposed to high temperatures, increased susceptibility to heat exhaustion.

The diagnosis of tellurium poisoning may be made from the garlic odor of the excretions, the suppression of the sweat, the dryness of the mouth, and the demonstration of tellurium in the urine or feces.

The preventive measures are similar to those used for other metallic poisons and may be summed up as good working conditions and proper personal hygiene.

In treatment, of course, the most important measure is the removal of cause. After that pilocarpin may be used to counteract the effect of the tellurium, and the avenues of elimination should be opened and excretion favored by promoting secretions, diuresis, and free bowel movements. Hydrochloric acid may be administered to remedy the deficiency of acid secretion. The remainder of the treatment is symptomatic.

The prognosis so far has been good, the condition gradually improving upon prompt removal of the cause. This is due to the fact that no serious cases have thus far been encountered. It is thought that the prognosis will be less favorable when more severe poisoning occurs as a result of greater absorption of tellurium incident to its increased production.

The 13 workers reported are still under observation and physical examinations will be made from time to time to observe their condition. New workers in the department will also be closely watched. Along with this, laboratory work is being done to determine more accurately the toxicity of tellurium and its effects upon the blood, blood pressure, kidneys, etc.

It is hoped that samples of the air which the men breathe may be collected while they work, so that determinations of the amount of tellurium taken into the lungs may be determined. Similar determination of the amounts ingested would also be of value, and it is expected that they will be made.

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Those interested in the study of tellurium may find some interesting data along historical, chemical, physiological, and pharmacological lines in the following references, many of which can be obtained from the library of the Surgeon General's office, U. S. Army. This bibliography is fairly complete.

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